Fermilab

TM-1067

THE BRASS PLUG MONUMENT SYSTEM FOR DOUBLER ALIGNMENT

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ABSTRACT

The system of brass plugs set in the Main Ring tunnel floor for use in radial alignment of Doubler elements is described. Considerations leading to the choice of plug positions and properties are discussed. The quantitative relationship between the plugs and the Doubler orbit is presented in sufficient detail so that they can be used by anybody to align Doubler elements both radially and along the beam. Neither the origin or the accuracy of the system is discussed in detail.

A set of brass plugs has been set and punched around the Main Ring which have the following deliberately chosen properties:

1. A plug is set at the mid-point of each Doubler four-dipole string such that it is radially offset inward from the mid-point of the Doubler orbit by 22.437". In missing magnet locations; i.e., stations 17½ and 48½, the plug is set with the same offset at the same geometrical location, namely, the upstream interface of dipole #4 (dipoles are numbered 2,3,4,5; at station 17, #2 and 3 are missing; at station 48, #2 is missing).
2. Straight lines joining neighboring plugs are parallel to the Doubler beam in the straight (be it a mini-, medium-, or long-straight) between the two plugs with an offset from the straight which is always 26.525".
3. The principal plug in the long straights is set at the "smoothed" Main Ring zero along the beam (an arbitrary choice consistent with a lot of work already published in the Design Report) with an offset of 26.525" (as decided above) from the Doubler beam.

In order to achieve the above properties, it was necessary to set two plugs at the missing magnet locations, namely 17½ and 48½: the inside (closer to the center of the ring) plug forms a line with the plug 97' upstream which is parallel to the upstream mini-straight (station 17 and 48) and is used for all alignment in the upstream 97', and the outside plug forms a line with the next downstream plug

which is parallel to the next downstream straight and is used for all downstream alignment. The inquisitive reader will understand the need for two plugs at these locations after careful comparison of Figs. 1,2, and 3.

The choices made above lead to the following operationally simple results:

1. Dipole support point offsets from the plug lines are always the same quartet of numbers (a,b,c,d in Fig. 1) even in the missing magnet regions. Present and future survey teams will not need special maps for special regions.
2. Since quadrupoles are parallel to lines joining plugs, misplacements of quadrupoles in z (the along-the-beam coordinate) has no coupling with their offset. Quadrupole offsets are critical to machine performance.
3. Dipole positions along the beam are always the same with respect to the nearest brass plug.

What is not invariant is the length of the straights and, therefore, the distance between brass plugs. The straight sections which are different from the "standard cell" are all long straights and stations 12, 17, 18, and 48. The enclosed figures illustrate these special straights.

Some comments on the definition of the Doubler orbit are necessary. In dipole strings, the orbit is approximated by circular arcs of length 252" per dipole, thus ignoring the small field-free region between dipoles. In the long straight sections, the orbit is that displayed in TM-1032, "The Revised Great Doubler Shift,"

including the difference between high-beta and low-beta straight sections. The only straight section in which the plug system is not parallel to the actual Doubler orbit is CØ, the scene of the abort scheme. The plug system, and TM-1032, both ignore the presence of missing half-dipoles at B48½ and C11½ and the Lambertsons in the middle of CØ. The beam in CØ is no longer "straight."

This plug system is the result of measuring the position of each Main Ring quadrupole with respect to its nearest neighbors and then "smoothing" that orbit by a mathematical prescription provided by Leo Michelotti[1] with the purpose of making the Doubler orbit a somewhat more perfect "circle" than the as-built Main Ring. The relationship between this plug system and the "smoothed" Main Ring orbit is given exactly in TM-1032. Persons interested in the differences between the "smoothed" Main Ring orbit and the real Main Ring quadrupole positions will need additional information which I can provide. The differences are typically 0.10" transverse to the beam and 0.2" along the beam. The smoothing operation will be described fully in another document.

The accuracy of the final plug system is still being studied but appears to be about 0.025" transverse to the beam and 0.060" along the beam. By "accuracy," I mean the rms deviations of the actual position of a plug from the desired distances to nearest-neighbor plugs. This accuracy is thought to be quite adequate for all Doubler elements except quadrupoles and spool pieces, which will need a final realignment relative to each other shortly before the ring closes.

ACKNOWLEDGEMENTS

Helen Edwards and Tom Topolski suggested the idea of placing plugs at bend points. Sho Ohnuma checked all the numbers which appear in the figures. The accuracy achieved is the result of thousands of hours of patient work by many members of the Alignment Group who pushed their instruments to the limits of the instruments' accuracy.

REFERENCE

[1]Leo Michelotti, UPC-140 and FN-338.

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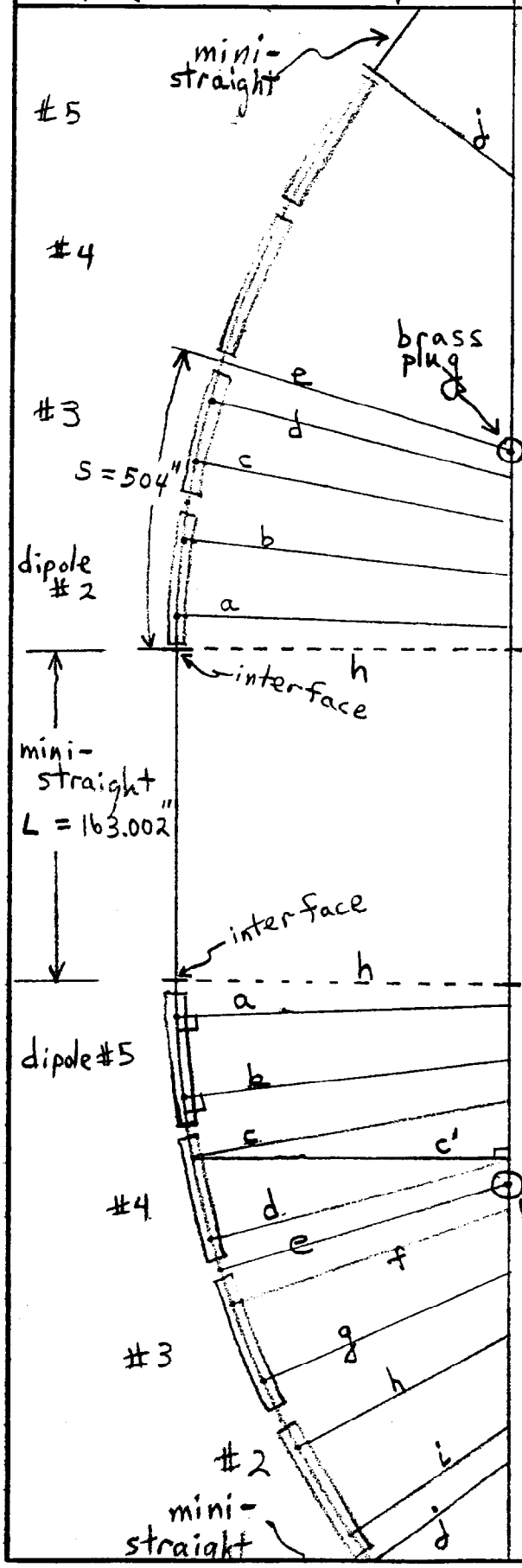
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
Saver	Doubler		1

SUBJECT: Doubler orbit offsets from brass plug line at magnet supports - NORMAL CELL

NAME: C.T. Murphy

DATE: 9/4/81 REVISION DATE:



name	radial offset	perpendicular offset
mini-straight	h = 26.525	
#5 DS, #2 US	a = 26.476	a' = 26.476"
#5 US, #2 DS	b = 25.900	b' = 25.900
#4 DS, #3 US	c = 25.008	c' = 25.007
#4 US, #3 DS	d = 23.280	d' = 23.278
mid point	e = 22.437	e' = 22.434
for use in "backward" shot	f = 21.496	f' = 21.492
	g = 18.615	g' = 18.611
	h = 15.937	h' = 15.932
	i = 11.903	i' = 11.898
begin next mini-straight	j = 10.166	j' = 10.161

Distance of support point to nearest interface = 55"

NORMAL CELL

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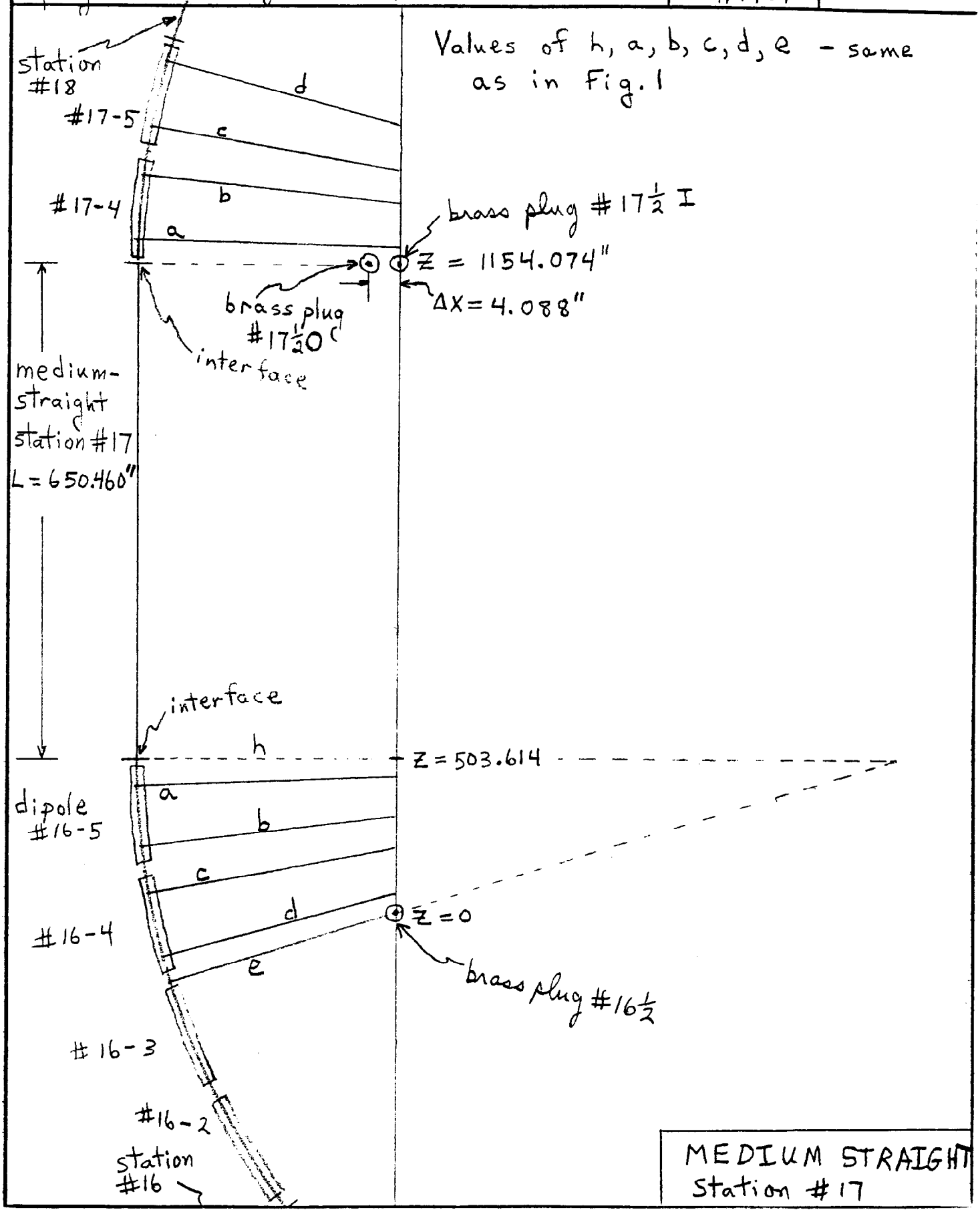
	Saver	Doubler		2

SUBJECT: Doubler orbit offsets from brass plug line at magnet supports - STATION#17

NAME: C.T. Murphy

DATE: 9/4/81 REVISION DATE:



MEDIUM STRAIGHT
Station #17

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ENGINEERING NOTE

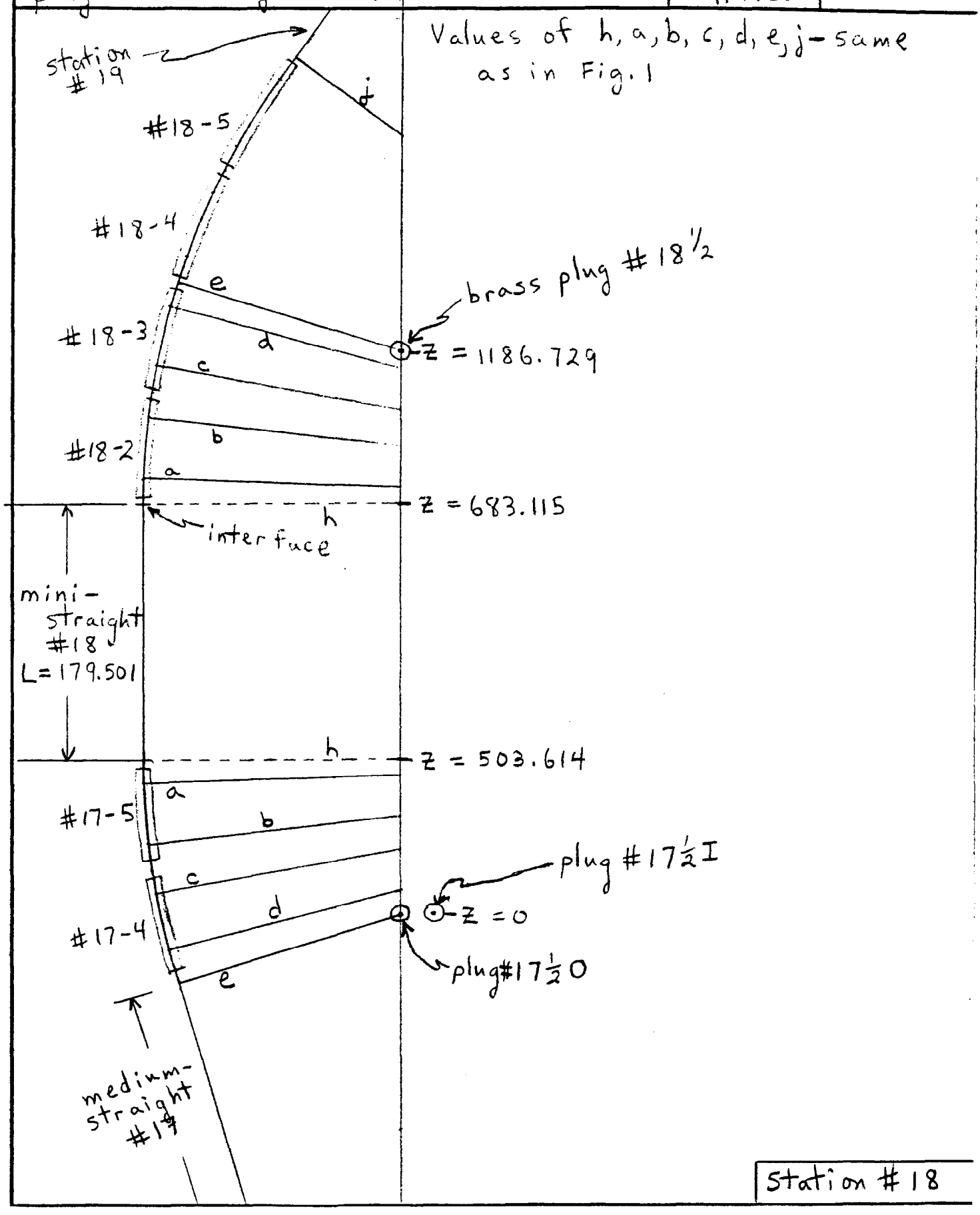
SECTION	PROJECT	SERIAL-CATEGORY	PAGE
Saver	Doubler		3

SUBJECT: Doubler orbit offsets from brass plug line at magnet supports - STATION #18

NAME: C.T. Murphy

DATE: 9/14/81

REVISION DATE:



Values of h, a, b, c, d, e, j - same as in Fig. 1

Station #18

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ENGINEERING NOTE

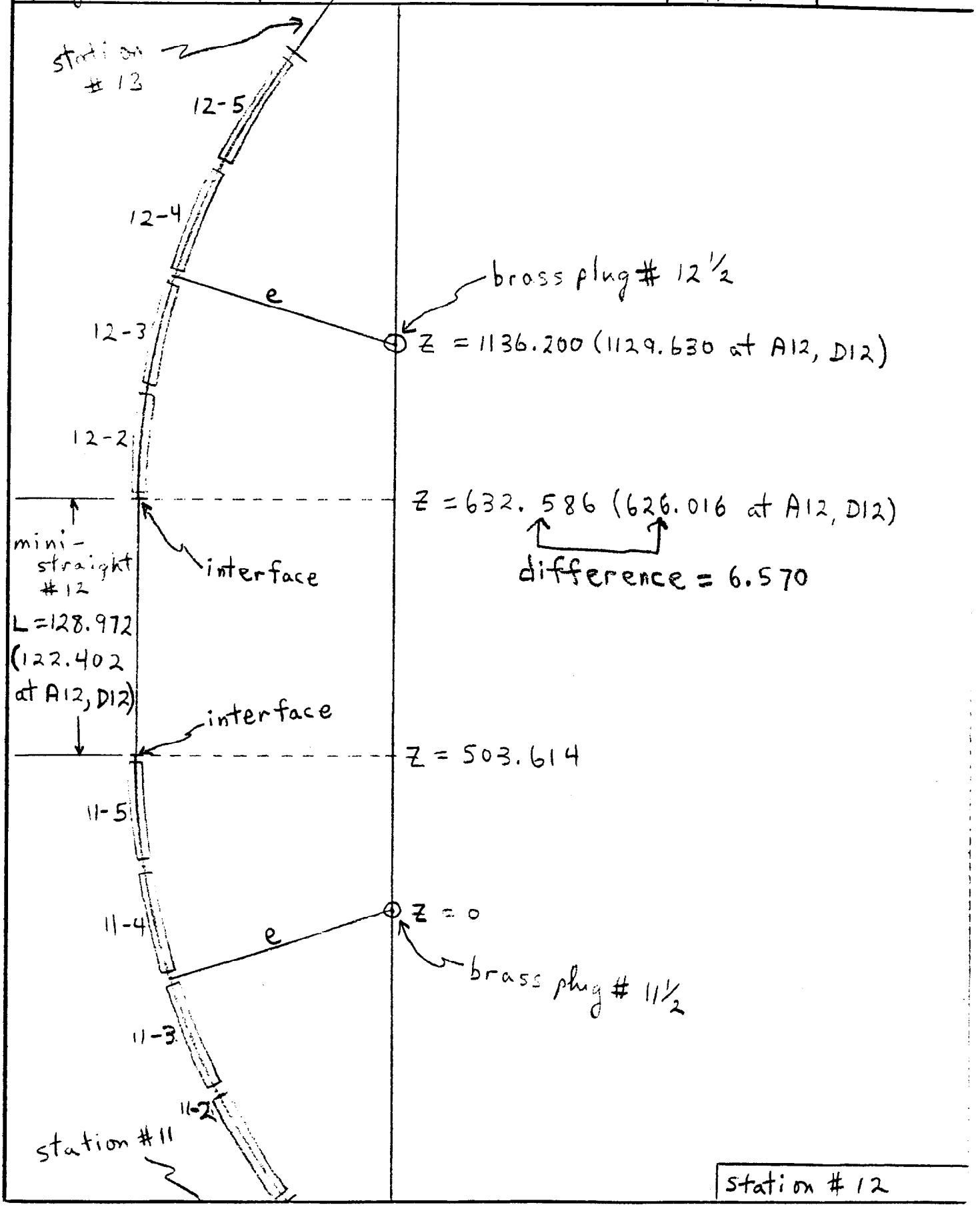
SECTION	PROJECT	SERIAL-CATEGORY	PAGE
Saver	Doubler		4

SUBJECT: Doubler orbit offsets from brass plug line at magnet supports - STATION #12

NAME: C. T. Murphy

DATE: 9/4/81

REVISION DATE:

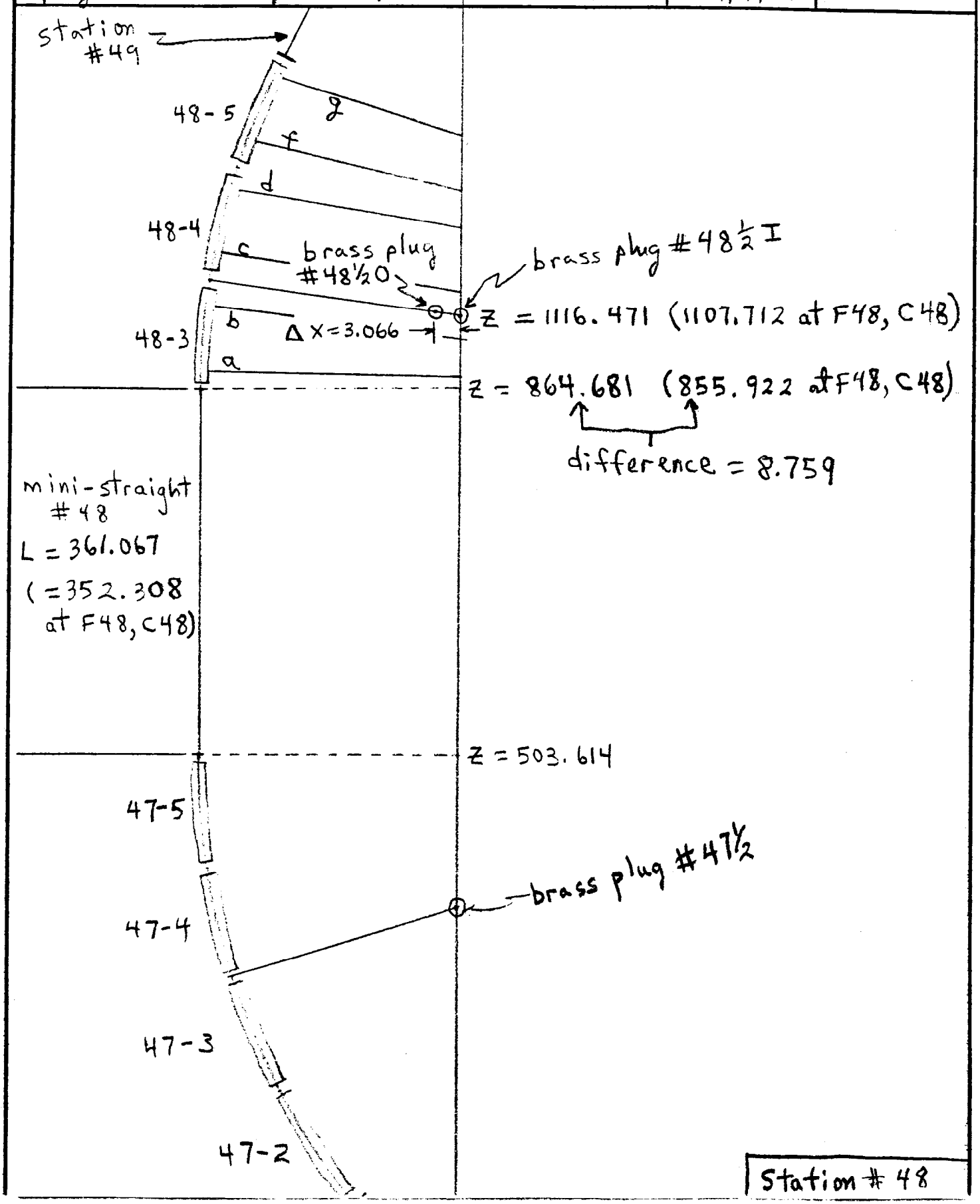


FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
	Saver	Doubler		5

SUBJECT: Doubler orbit offsets from brass plug line at magnet supports - STATION#48

NAME: C. T. Murphy

DATE: 9/4/81 REVISION DATE:



Station # 48